Note that Bob Whittier has a lot more detail he has gone into, at the level of an SOP/SAP, but below I am just focusing on getting the purpose/objectives locked down.

Comments on: Draft Work Plan Outline (2021-07-12)

Section 1 – Introduction and Section 3 – In-Well Testing Rationale and Design

Based on our discussions over the last 24 months, I believe that the core purpose of the study is to obtain information on the local scale directions and rates of groundwater flow, as inferred from measurements made within individual boreholes using "intra-well" as opposed to "inter-well" techniques. Intra-well studies will be conducted at different vertical placements within the open-screened interval of each tested well to determine whether there is variation in these quantities at each well location. To the extent practical, I understand that intra-well studies will be conducted both with Red Hill Shaft (RHS) pumping, and not pumping, to identify whether there are measurable differences in these quantities between pumping and non-pumping conditions (this is stated in Section 4 at various locations but should be indicated up-front in the purpose/objectives).

Once results from the intra-well studies have been obtained, these can then be combined via inter-well comparisons to infer the variability in directions and rates of groundwater flow, and whether any consistent (systematic) patterns of variability – such as trends – are present or whether the inter-well variability appears to be unsystematic and essentially random. Information obtained from the intra-well studies and inter-well comparisons will be used to corroborate or update and refine the local (RHBSF-focused) conceptual site model (CSM). Subsequently, if necessary and appropriate, these data and the updated CSM will be used to update and potentially re-calibrate one or more of the numerical groundwater flow models.

Section 3.2 – Scale of Testing

This is an important statement: "Since in-well testing provides information at a localized scale, it may not be directly comparable on a well-by-well basis to the information presented in the CSM and GWFM reports." We will need to look to Dr. Becker for his guidance on how information from intra-well studies is upscaled or otherwise compared to larger-scale modeling and mapping studies. It would be good to add additional information to this statement regarding the suite of potential, common, methods for accomplishing this.

Section 4 - In-Well Testing Implementation

Following from the call on 8/3, I do wonder whether slug testing or a similar method makes sense to undertake. No, its not absolute nor as reliable on a large scale, but it can definitely provide information on relative transmissivities between wells. Since the individual borescope/other tests will be similar in some sense (they don't directly measure velocities in the aquifer materials, but give a sense of direction and relative velocities) I think the slug tests fall into the same category of information – good relative measures comparable between wells, but for absolutes on the scale of RHS/RHBSF we will need to rely on methods like the TFN work already completed. Obtaining these measurements contemporaneously and as part of the same field program as the in-well borescope etc. testing would be a nice way to provide a tidy package.

(*Note: I don't recall if slug testing was previously performed in the wells – I seem to recall it may have been in a subset, but not in all. Note also that pneumatic tests can be used if a sizeable mechanical slug cannot easily be inserted in the well. And finally, Wilson et al (1997) provide a little info on slug testing compared with simple bail-down tests, and their relative values).

Comments on: Worksheet #1: Project Quality Objectives (PQO)/Systematic Planning 1 Process Statements (2021-07-12)

Overall this is a good start and outline. There are some uses of terms (based on my experience which is dominantly under CERCLA) that it would be good to clear up.

Section 1.1 - is Worksheet #1 going to be an Addendum to the main Work Plan? Because I am not sure the first sentence in Section 1.1 is entirely accurate, it seems copied from the main Work Plan. This Worksheet should be introduced as the document addressing the specific PQOs/SPPS of the planned Study.

Section 1.2 – the term principal study question (PSQ) is first introduced here and is the terminology I am more familiar with (PSQ and DQOs, versus PQO and SPPS, although I am very familiar with the systematic planning process). I think it would be good to define for purposes of this study the overlap and the differences between PQO and DQO since both terms are used. As I understand it, DQOs can often dig down into specifics of acceptability of data for intended uses, etc., whereas PQOs are often used at a slightly higher level to define what data will be collected, for what purposes, and who will be the recipients and users of the data. In this sense, as I understand it, PQOs can be less restrictive on the "quality" and end-uses of the data, as long as the data are gathered as planned, and processed, and distributed as intended to the end users. In this sense, PQO may be the best term / approach for this study - but a definition from the navy perspective for this study would be helpful.

Section 1.3 – may consider adding slug testing/pump-down testing to this, as noted above in comments on the main Work Plan.

This section is open on the quality of the information and the quality control procedures. I believe this would be the "meat" of the DQOs (as opposed to PQOs, noted above). Quality control protocols are good; and I would emphasize the manufacturer criteria for the equipment used, and that any explicit dos/donts therein are followed, but not define quantitative/%margin/acceptability criteria or get too quantitative/prescriptive on the DQOs, because of the difficult setting and what is an exploratory study. I have seen %margin acceptability criteria defined before field studies that upended the work. We don't have explicit thresholds in play here such as standards (although there may be PQLs at play, see Section 1.6).

Section 1.4 – recommend adding a simple figure defining the horizontal extents, so that everyone visualizes the area this study is focused on (essentially, an envelop around the traditional wells)

Section 1.5 – this is always the rub. What is "consistent" and what is "differ substantially". To get started, we need an earlier section or statement that defines what the CSM and GWFM reports "present", so we know what we are comparing to and can have an understanding of what "differ" means. For example (and this is just a first cut):

- *"Although the various GFWMs constructed by the Navy demonstrate some differences in groundwater flow patterns, the CSM and GWFMs collectively depict fairly uniform groundwater flow conditions beneath the RHBSF, with the direction of flow being predominantly makau-to-makai under simulated hydraulic gradients that are on the order of one foot in 500 feet (0.002)."*

Section 1.6 – please see comments on Section 1.3. In addition, though this is not a "lab" study, do the manufacturers have published PQLs for their instrumentation, so we have lower-bounds on what is measurable and meaningful. Documenting these can be very important when dealing with Section 1.5 and what is consistent or inconsistent.

Section 1.7 - may consider adding slug testing/pump-down testing to this, as noted above in comments on the main Work Plan